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NEW OR LITTLE-KNOWN PERMIAN VERTEBRATES¹
TREMATOPS, NEW GENUS

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Of the numerous specimens obtained from the famous Permian deposits of northern Texas the past year by the University of Chicago Expedition, none is of greater interest than one represented by a nearly complete skeleton of a new rhachitomous amphibian allied to *Eryops*, discovered by Mr. Paul Miller at Craddock's Ranch, near the town of Seymour. The specimen was found fully exposed on a gently sloping surface, intermingled with the remains of a reptile which seems to be of a new genus of *Cotylosauria*, which will be described later. At the time of the discovery it was not suspected that more than a single individual was represented by the remains, the bones of the amphibian, save of the skull, being almost wholly inclosed in a more or less weathered mass of hard matrix. Recognizing in the skull some of its peculiar characters, Mr. Miller and I spent several hours in a careful search for all possibly recoverable fragments. Evidently both skeletons had been, originally, nearly complete as preserved in the clay beds, and both were probably close together, but erosion has destroyed or mutilated much of the reptile and some parts of the amphibian. The separation of some of the parts of the amphibian skeleton which had been washed free from their matrix from the remains of the reptile has been difficult. Fortunately, however, nearly all parts of the amphibian skeleton, save the radius, fibula, and most of the tail, were found in anatomical relations in the blocks of matrix.

The incrusting matrix which adhered to most of the bones, while fortunately preserving the specimen from ruin, was very hard, requiring nearly two months of patient work on the part of Mr. Miller to remove. That these specimens, which must have been exposed for

See "The *Cotylosauria*," this journal, XVI, 139; "*Lysorophus*," *Biological Bulletin*, XV, 229; "*Diplocaulus*," *Transactions Kansas Academy of Science* (in press).

a score or more of years, should have escaped the observation of previous collectors in this much searched-over region is remarkable, and only goes to show that these, like most other fossiliferous beds in the West, will never be exhausted. It gives me pleasure to name the species in honor of Mr. Paul Miller, whose keen eyesight and patient labor have brought not only this specimen to light but also many others in the University of Chicago Museum and the American Museum of New York City.

Trematops milleri, Genus and Species New

Skull (Figs. 1, 2, 3).—The skull of *Trematops* is remarkable, not only among amphibians, but also among Permian vertebrates, for the association of certain peculiar characters widely distinguishing the genus from any other now known. The chief of these characters are: the possession of a median unpaired rostral opening leading into a palatine vacuity; greatly enlarged antorbital vacuities; a temporal fenestra; and the apparent absence of the parasphenoid bone of the palate. In the skeletal characters, aside from those of the skull, the genus does not differ much from *Eryops*, so far as known, and doubtless the skeletons of each, when fully known, will show a like agreement throughout.

In shape the skull is subtriangular, its width posteriorly being but slightly less than the length from premaxillae to occipital condyles. Its surface is coarsely and rather deeply pitted, but presents no traces of mucous canals that I can distinguish. The face is markedly constricted just in front of the orbits, the facial region showing a slight lateral convexity on the outer sides of the large antorbital vacuities. Back of the orbits the "table" of the skull is broad and nearly flat, perforated by the rather small parietal foramen near its middle. The orbits are oval, their greater diameter oblique to the longitudinal axis of the skull, their borders thickened in front and behind, but thinner above and below, with the plane of their margin looking obliquely forward, upward, and outward. Immediately back of the orbit at its outer part, the table turns downward, forming the anterior bar of the temporal vacuity. The upper margin of this vacuity is perfectly preserved on the left side, but the fragments forming it were not recovered for the right side of the skull. It is thinned, in outline

gently concave and turned outward, and, posteriorly, a little downward, forming the lateral margin of the flat table of the skull. The natural character of the border is beyond dispute, the small pittings

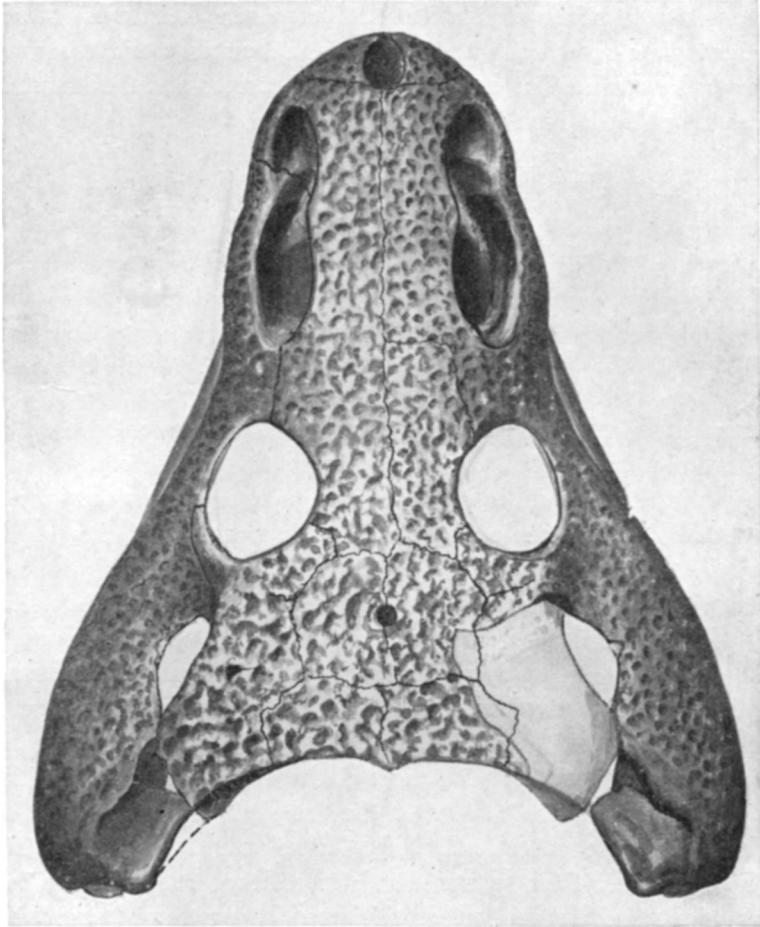


FIG. 1.—*Trematops milleri* Will. Dorsal view of skull; three-fifths natural size.

of the surface continuing quite to the junction of the upper with the lower surface of the cranial bones. There is no possibility of its union, either by suture or fracture, with the lateral walls of the skull. In front the vacuity continues in a shallow, lateral groove, nearly as far

forward as the orbital margin. On the right side the upper margin of the vacuity, as stated, is not preserved, but the natural rounded border of the opening is found on the lower and partly on the front side, giving, with the left side, practically the outline of the vacuity throughout, save at the narrowed posterior end. The cavity was oval in shape, about twenty millimeters in length, looking outward, and a little upward and forward. There remains the bare possibility that the enlarged vacuity was connected by a slender and sinuous isthmus with the outer posterior margin of the skull, but I do not think so. In position, it is seen that the fenestra is nothing more nor less than a greatly elongated and closed epiotic notch, and this interpretation is confirmed by the disposition of the bones on the under, palatal side of the skull. Other genera of stegocephs have the epiotic notch closed posteriorly, but I know of none in which it extends nearly so far forward as it does in this genus. As an epiotic vacuity it conveys the suggestion that the origin of the lateral temporal vacuity in the double-arched or saurocrotaphic reptiles has arisen, not by a natural trephining of the skull wall, but by the inclusion of an epiotic notch. From the fact that the so-called squamosal bone borders the vacuity above, it would hardly seem to be homologous with the superior temporal fenestra. However, it is by no means sure that the superior bone is the real homologue of the squamosal of the higher animals. I have followed Baur in so considering it, but I by no means believe that its squamosal or supratemporal character has yet been demonstrated.

The sutures, for the most part, in the skull are indistinguishable or distinguishable with difficulty from the cracks. On the upper surface of the table, however, they are very conspicuous, as shown in the illustrations. The parietals, it is seen, are rather small bones, uniting by a transverse suture with the so-called supraoccipitals behind.¹ The shape of the postfrontals is clearly shown, but the postorbitals are indeterminable. Nor can I make out the limits of the

¹ It has long been known that these so-called supraoccipitals of the stegocephalan and cotylosaurian skulls are not the real supraoccipital of the mammals and higher reptiles, but are membrane bones. Perhaps the best name that has yet been applied to them is that of Broom—the postparietals. In a later paper I shall figure both the cartilage supraoccipital and the membrane supraoccipitals in the same specimen, not even suturedly united.

epiotics and "squamosals" or "supratemporals," though the two bones very clearly form the outer part of the table. The frontal bones terminate a little in front of the orbits by a nearly transverse suture,

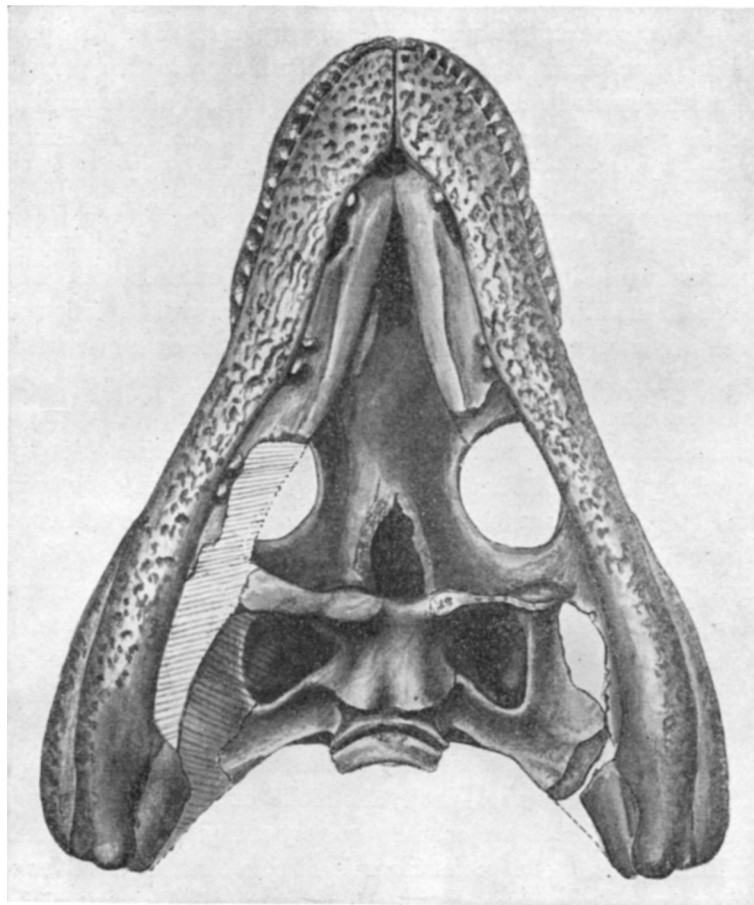


FIG. 2.—*Trematops milleri*. Palatal view of skull; three-fifths natural size.

and, of course, the nasal bones form that portion between the antorbital vacuities, as far forward as the rather small premaxillae.

At the very front of the rostrum there is a rather small, but perfect, median, unpaired vacuity leading into a foramen in the middle of the palate below. I am at a loss to say what its real nature is. If not a

median narial opening, I cannot see why there should be a palatal opening below it. It is not for the passage of teeth, as in some labyrinthodonts. A median opening is not unknown among the Stegocephala. *Dasyceps*, from the Permian of Kenilworth, has a large, elongate opening between the nasals, and *Acanthostoma*, from the Rothliegendes, has a moderately large median vacuity between the large nasals and the premaxillae.

The greatly enlarged and elongated openings on the sides of the face in front of the orbits are, in part at least, merely antorbital vacuities; of this there can be no doubt. The anterior portions, however, seem to be the real nares, in position like those of *Eryops*, and opening into a vacuity at the outer side of the palatine and vomers of the palate. A flattened or concave bone is seen in the right fossa, directed obliquely backward. It may be a turbinated bone.

The occipital condyles are parial, the gentle concave articular surfaces looking backward, a little downward, and toward each other. A specimen of *Eryops* in the collection shows, I think clearly, a transverse suture a little in front of these processes separating them from the part in front which I believe to be the basisphenoid, and just back of a pair of flattened or spoon-shaped processes, corresponding to the hypophyses of the reptilian basisphenoid and occipital region. In front of these processes the bone is gently concave from side to side. In the middle in front there is a rounded heavy margin, which shows no traces of a bony prolongation, as in *Eryops*, into the median parasphenoid. On either side in front the basisphenoid turns downward in a thickened process, quite as in *Eryops*, to articulate with the pterygoids. On either side, posteriorly, from the basioccipital processes a groove runs outward and upward, bounded in front and behind by bars of bone. At about 30^{mm} from the middle line this groove turns at an acute angle forward nearly parallel to the median axis of the skull to terminate at the outer end of the pterygoids, and leading into the temporal vacuity. The bone containing this groove shows at its inner extremity a distinct suture separating it from the occipital and basisphenoid. It is doubtless in part at least the paroccipital.

The pterygoid, from the basisphenoid articulation, turns trans-

versely outward as a vertical plate, ending in a sutural articulation, just back of the orbit, with the anterior end of the bony ridge bound-

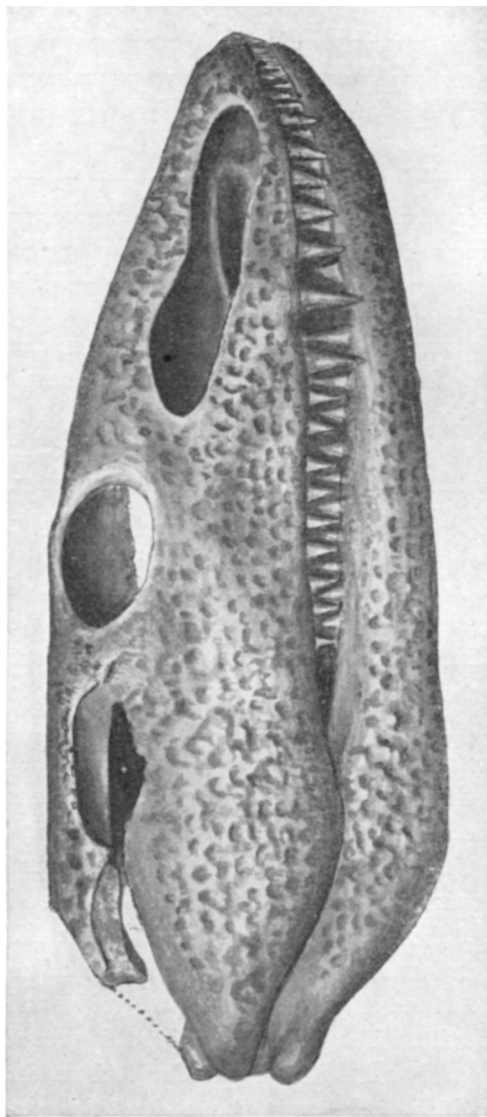


FIG. 3.—*Trematops milleri*. Side view of skull; about two-thirds natural size.

ing what I believe to be the otic groove. The plate does not seem to reach quite to the roof of the skull in its middle part. The under margin of this plate is widened a little antero-posteriorly externally. Its outer extremity is lost, but it doubtless unites with the palatines at the outer side of the palatal surface, and probably sends back a posterior process at the sides to connect with a broken extremity of a flat bone on the inner side of the quadrate. The attachment of this bone, or of a separate transverse bone, is shown by a broken edge turned downward a little below the plane of the palatines to abut slightly against the upper inner margin of the mandible. There is no indication of a median parasphenoid prolongation in front of the basisphenoid, but a broken surface of a bone forming the brain case for the cerebrum may

perhaps represent what is left of the parasphenoid, which must in this case be far above the plane of the palatines and closely applied to the under side of the brain and its rhinencephalic anterior prolongation. The palatines, or the combined palatines and pterygoids, form a narrow horizontal shelf along each maxilla. The inner part of this shelf is thickened, so that its median border forms nearly a flat surface directed inward and downward, and separated by a depression or groove from the outer palatal surface. Probably this portion represents the anterior prolongation of the pterygoids, but I can distinguish no trace of a suture between the two portions. The palatal shelf of the left side was crushed against the opposite side in the specimen, lying quite in contact nearly as far back as the orbits. There could not have been any median parasphenoid between the two parts, the angle anteriorly being acute and the palatines or vomers meeting and coming closely in contact anteriorly. The internal nares are oval vacuities situated nearly below the anterior part of the lateral facial vacuities. Just in front of the opening on each side and close to the margin of the mandible, as articulated, there is a large tooth, doubtless situated upon the vomer. There are four large teeth upon the palatines, also attached so that they come closely in contact with the inner side of the mandible in the closed mouth. These teeth are in two pairs. The first pair, of which the anterior one is the smaller, are situated a little in front of the orbit, the apex of the larger tooth reaching nearly to the lower border of the mandible. It has a length of 22^{mm}, with a width of 12 at its base. The posterior pair, of nearly equal length, measuring about 12^{mm} each, are also closely applied to the inner side of the mandible a little back of the middle of the orbit.

Teeth.—There are twenty-five or twenty-six teeth in each of the upper series, and about the same number in each mandible. Six of these, of rather small size, are attached to the premaxilla in front of the lateral narial opening. The longest measures 8^{mm}. The largest of the maxillary teeth are situated back of the middle of the narial vacuity, two of them measuring 14 and 15^{mm} in length, by 5^{mm} in diameter at their base.

The mandible is rather slender, with a short symphysis, where the somewhat expanded bones form a shallow but short trough, the

two together below gently convex from side to side. The lateral outlines of the mandibles from below have a gentle concavity near the middle, curving rather strongly inward behind. The inferior margin of the jaw turns upward behind rather abruptly, and is narrowed from side to side. The sutures of the mandible are not certainly distinguishable. Posteriorly the articular projects but very little beyond the quadrate.

Vertebrae (Figs 4 ff.).—The remains of twenty-three vertebrae are preserved in an uninterrupted series connected with the occipital condyles. Of these the sixteenth, seventeenth, eighteenth, and nineteenth are represented by their arches only, their centra lost from the block of matrix wholly or for the most part. As far as the fifteenth the hypocentra lie closely associated, save for a twist at the seventh, in a somewhat sigmoid curve, with the spines vertical or nearly so. At the sixteenth the column was twisted so that the spines lie horizontally to the right, the left leg with its parts but little disturbed lying for the most part upon or at the right side of the column with its ventral side uppermost. The femur is much flexed upon the leg and its head turned across and above the posterior vertebrae. At the end of the twenty-third, or rather in the twenty-fourth, another break occurs in the series as preserved in the matrix. The succeeding block of matrix includes four vertebrae, and was much worn. Erosion of the projecting ends of the series in the two blocks prevent their positive union. The first eroded vertebra of this series bears the left sacral rib, and, lying above it, the proximal part of the left ilium. By joining the two eroded ends of the series with the acetabulum lying uppermost, the head of the femur nearly fits into it. It is certain that the leg suffered no disturbance whatever after the decay of the flesh covering it, save a slight rotation of the tibia outward and the displacement of the fibula. It clearly occupies its proper position as regards the vertebral column, from which it follows there could not have been more than one or two vertebrae lost.

The axis is much broader from side to side than the following vertebrae, and is very short antero-posteriorly. Its large articular surfaces fit closely the condyles of the skull. Its posterior margin below is nearly parallel with the anterior. I can discover no indications of separated pleurocentra, though such may have existed. Its

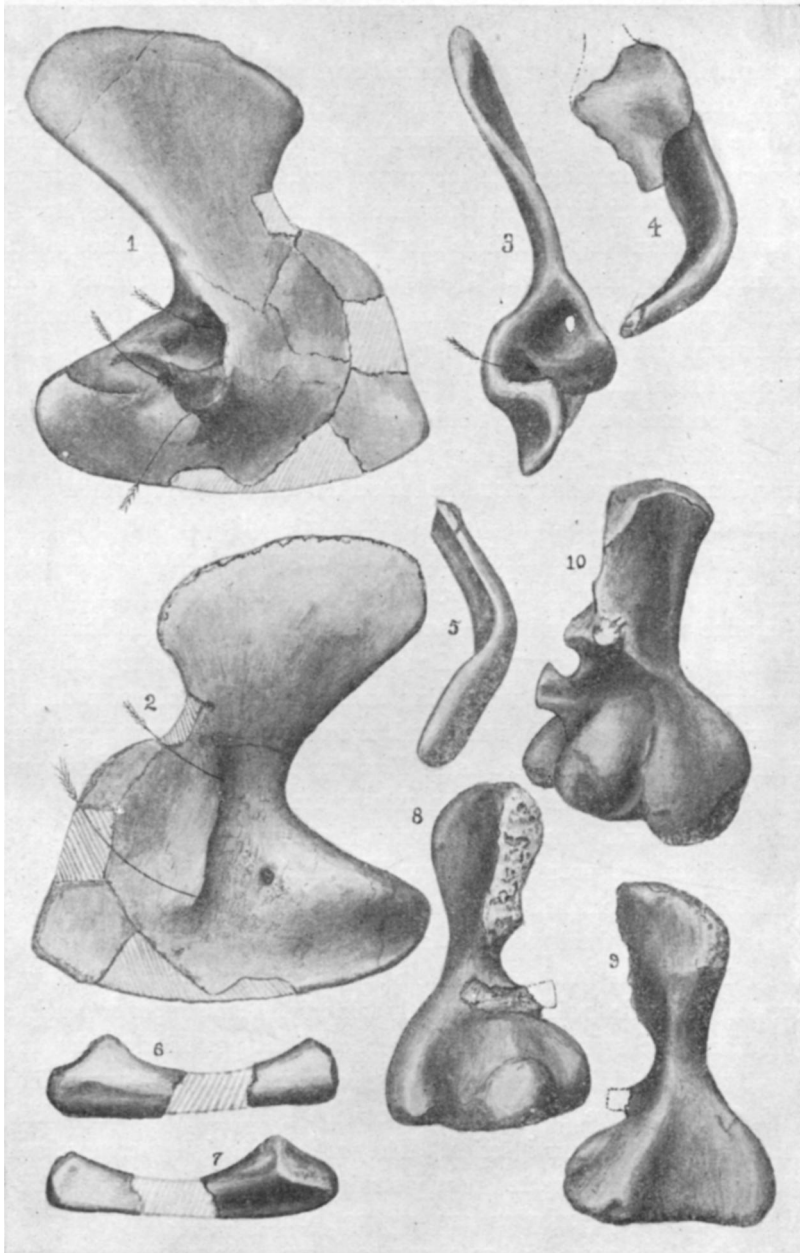


FIG. 4.—*Trematops milleri*. 1, right coraco-scapula, from without; 2, the same, from within; 3, the same, from behind; 4, interclavicle and right clavicle, from above; 5, right clavicle, from behind; 6, left ulna, from within; 7, the same, from without; 8, left humerus, from in front; 9, the same, from behind; 10, *Eryops*, right humerus, one-third natural size. All figures, except as noted above, two-thirds natural size.

separated neuropophyses are vertical and slender, widely separated from each other above by the massive spine of the second vertebra. Above the middle of each neuropophysis there is a small posterior zygapophysis for union with the second vertebra. The hypocentrum of the second vertebra is much smaller than the following ones, transversely oval in shape. There may be pleurocentra here also, but I cannot distinguish them. The spine is very massive above, with strong rugosities posteriorly, broad from side to side, with the slender neuropophyses of the axis lying in contact with it in front. The hypocentra of the succeeding vertebrae are almost identical in size and shape, scarcely varying a millimeter in length or breadth, though those of the sacral region may be a little stouter. Where best preserved they show a flattened surface on the under side separated by a ridge from the sides, though in others this flattened part seems to be merely a rounded keel. Many of the pleurocentra have been dislodged, but such as are in position in different parts of the column are alike in shape and in attachment, all rather smaller than the anterior or mesial ones of *Eryops*. The longer neuropophysial attachment is with the succeeding arch. These attachments of the pleurocentra leave only a small surface on the hypocentrum for union with the arch, which, here as in *Eryops*, for the most part is more closely united with the pleurocentrum of the preceding vertebra than with that following the arch, to which it presumably belongs. Complete spines are present in several of the anterior and posterior vertebrae, but lack their distal extremities in most of the others. As is the case with the hypocentra and pleurocentra they are all nearly alike throughout in thickness and length. They are a little compressed from side to side, and slightly thickened at the upper extremity. Anteriorly the spines are nearly vertical, but posteriorly they are slightly inclined backward. The transverse processes, springing from the arch, are also, so far as can be determined, nearly alike throughout the presacral series. They are stout, slightly compressed vertically, and are directed nearly straight outward, or a little backward. The zygapophyses are rather better developed than in *Eryops*, and are not placed so closely together, their articular facets at an angle of about forty-five degrees. The transverse process for the sacral rib is very stout and heavy, with its large articular facet directed

outward and downward. There is but one true sacral vertebra, though the transverse processes of the vertebrae immediately preceding or following the sacral are heavier than elsewhere. Altogether the vertebrae of *Trematops* are very much like those of *Eryops*, the pleurocentra anteriorly somewhat smaller, the transverse processes somewhat longer and stouter, and the zygapophyses a little better developed. Of the caudals, save the two connected with the sacral vertebrae, only one small block of matrix containing several more or less confused bones of the distal part of the series is preserved. The chevrons are stout and short, united above in a heavy hypocentral mass which is excavated in its middle for the notochord. In front of one of the preserved chevrons there is a pleurocentrum which seems to have separated the hypocentra ventrally.

The ribs are everywhere short. For the first nine or ten vertebrae they are much dilated, both proximally and distally, with the distal portion twisted somewhat from the plane of the proximal. They have a slight but distinct curvature. In the region of the fifteenth vertebrae the ribs are much smaller, with the proximal portion less dilated, and with a longer, rounded shaft. The first rib preserved in the matrix has its head closely applied to the side of the second vertebra. The attachment of the ribs, at least anteriorly, was to both the transverse process of the neurocentrum and the pleurocentrum or hypocentrum, though no articular face is visible. The sacral rib is quite like that of *Eryops*. It has a broad, stout, proximal portion articulating chiefly with the transverse process, but also below and in front with the hypocentrum or region between the hypocentrum and pleurocentrum; the distal part is much flattened and expanded, and is curved downward.

Pectoral girdle and extremity.—Scapula-coracoid (Fig. 4). The right side of the pectoral girdle was found inclosed in the matrix close to the skull, lying on the sides of the anterior vertebrae. The preserved parts are very complete. Some fragments of the border of the coracoid, and the tip of the clavicle only are missing. The united bone, on the whole, resembles that of *Eryops*, save especially in the absence of the cleithrum, which is large and stout and closely applied to the front border of the scapula in *Eryops*. The scapula is much expanded above, and is flattened, a little

thickened posteriorly, the planes of its outer and inner surfaces directed a little inward anteriorly. The scapula narrows rapidly to within a short distance of the glenoid fossa, and then is widely expanded antero-posteriorly for the coracoids. That portion corresponding to the procoracoid of the allied reptiles is a little thickened, nearly flat, and directed somewhat toward the visceral side. The lower anterior angle is nearly rectangular, and the mesial border of the whole bone is gently convex in outline, and is somewhat thinned. Posteriorly the rather narrow coracoid projects strongly backward, its narrowed extremity thickened and strongly curved toward the visceral side. The deep glenoid cavity is directed upward, backward, and outward. Above, the thickened hind border of the scapula divides, inclosing between its two branches a rather deep non-articular fossa. The anterior or external branch continues downward in the same plane and direction as the scapular border, ending in a sub-triangular, articular facet looking backward and outward. The end of the humerus lay in immediate apposition with this facet. The posterior continuation of the scapular border, the thicker of the two, curves inward and backward, in a strong, nearly semicircular sweep to near the extremity of the coracoid. Between these two divergent borders, there is a deep cavity or fossa, evidently no part of the real glenoid fossa, pierced by a large foramen or fenestra at its bottom. Just below the lesser ridge which bounds this fossa posteriorly from the glenoid cavity, running from the internal angle of the humeral facet upward and backward, and near its middle part, there is a second foramen, which opens on the convex surface of the inner side of the bone. A third foramen is seen below the humeral facet, opening on the inner side at the lower end of the vertical flexure. This must be the true supracoracoid foramen, through which the scapula-procoracoid suture doubtless passes. The true glenoid fossa is limited below posteriorly by a strong declivity. The inner surface of the scapula above, like the exterior, is nearly flat, the lower surface convex in front. Just back of the glenoid cavity and corresponding to the vertical margin of the outer side, the bone on the inner side turns abruptly outward, save on the lowermost portion, bounding in front a posterior cavity into which opens the supraglenoid and the supracoracoid foramina, above and below, as shown by the arrows in

the figure. In front of the border the surface of the bone is strongly convex from above downward, and somewhat so from side to side. This surface is pierced near its middle by the glenoid foramen.

No sutures are visible distinguishing the bone into its three elements. As regards the cleithrum, there is a total absence of all indications of such a bone as occurs in *Eryops*, either on the upper or anterior border (Fig. 7).

Clavicle and interclavicle.—The right clavicle was found in the matrix nearly in its anatomical position, its upper end only gone. It is very small for an amphibian, and has lost every trace of the pittings so characteristic of the stegocephalan clavicles on its outer surface, though not unlike the clavicles of *Eryops*. (See Williston, *Kansas University Quarterly*, VIII, 185, Pl. XXIX, Fig. 2.) The clavicle is bent near the middle nearly at a right angle, and somewhat twisted. The proximal part, underlying the interclavicle, is but moderately expanded—less so, in fact, than in the contemporary reptiles, and not twice the width of the distal part. Its anterior border is thickened, its posterior, somewhat everted portion is thin. The scapular extremity is lost, but there is some, though doubtful, evidence of the possession of a small cleithrum, shown by a fragment of a small bone apparently attached to it. The greater part of the interclavicle is present in the specimen, lying on the under side of the procoracoid angle of the scapular bone. The bone is flattened and expanded transversely, with a short lateral projection on each side, and a thin but broad anterior margin. In the middle, posteriorly, the bone is slightly thickened, but there was no median posterior elongation, as in the reptiles. The interclavicle is remarkable for its small size, and thinness, as well as for the entire absence of external pittings. As a whole, the clavicular, as well as the scapular girdle is markedly reptilian in character, far more so than in any other known amphibian.

Humerus.—Lying closely articulated in the right glenoid cavity was the proximal inner side of the right humerus as far as the median constriction. The outer proximal part had been eroded away, and of the distal portion only the outline of the bone, and the inner distal part remained. Of the left humerus almost precisely the same proximal part was found loose in the wash, together with the distal half, with the exception of the inner distal part, that part left in the

matrix of the right humerus. The two bones hence give the characters of the complete humerus with the exception of the proximal outer part. The humerus resembles not a little that of *Eryops*, a figure of which, more reduced, I have given for comparison (Fig. 4), although a little more slender, as are, indeed, all the bones of the extremities. The two expanded extremities are twisted at an angle of about sixty degrees, the shaft between them abruptly and much constricted, about 8 by 10^{mm} in diameter. The proximal anterior face is somewhat concave. The distal portion has a large rounded radial convexity on its outer side, above which, separated by a groove at the outer side, is a small process, evidently quite like that of *Eryops*. The inner condyle is somewhat thickened; the entepicondylar margin is convex from above downward, but wholly without an epicondylar foramen, such as is present in the related genus *Acheloma* Cope.

The two extremities of the right ulna were found free in the wash, distinguished from the reptilian ulna found with the specimen by their much smaller size and the less produced olecranon. I have figured them in the plate (Fig. 4), separated by the same relative distance as those of the ulna of *Eryops*. The proximal portion is convex on the inner side, thinned above and below. The outer side is concave for the radius, with the humeral articular surface, or sigmoid cavity, showing more from that side. The olecranon is rugose. The distal extremity is but slightly expanded, a little thickened in the middle at the end, gently convex on the dorsal, and concave on the palmar surface.

The extremities of what I believe to be the radius are among the fragments recovered in the wash, but the present impossibility of distinguishing them from the reptilian remains renders their description inadvisable. I have outlined the bone in the restoration from *Eryops*.

A mass of matrix containing nine carpal bones united in their proper relations was secured. Their distinction from the reptilian specimen is assured by their smaller size, and the determination of the carpal bones in that specimen. Their relative size and position, as I determine them, will be seen in the restoration. It is evident that two of the proximal bones are missing, and they are shown in shaded outlines in the figure.

Pelvic girdle and extremity (Fig. 5).—The left ilium was preserved attached to the sacral vertebra and rib, nearly or quite in normal position, but considerably eroded on its outer surface. The acetabular portion of the same side, found loose, shows also considerable erosion of the surface, and the precise connection with the ilium worn off; the symphysial portion also of both ischium and pubis is wanting. The ilium resembles somewhat that part in *Eryops*, but is broader, less elongate, and thinner. The acetabular part is quite similar to that of *Eryops*, and it is quite probable that the missing portion below will be found also like that of *Eryops*. The acetabulum is large and shallow, with a thickened rim in front, a rounded protuberance at the upper part, and a thickened margin at the lower posterior part. The pubic foramen below the anterior part of the acetabulum opens on the inner side toward the front margin.

Femur.—The left hind leg (Fig. 5, 1) is preserved almost completely, and with but little disturbance of its parts, lying partly upon, partly at the right side of the vertebral column, its ventral side uppermost, the femur much flexed and inclined over the vertebrae to meet the acetabulum, which was lying nearly horizontally. The femur resembles in miniature that of *Eryops*. Its proximal extremity is thickened, transversely convex above, much thickened on the inner side, less so on the outer, and with a shallow fossa behind, externally. The shaft is much narrowed from side to side at the lower third. The “lesser trochanter” is robust, beginning about one-third the length of the bone; its face is oval in outline, with a longitudinal groove, and is directed proximally and ventrally. The “linea aspera” continues the trochanter as a high, thin longitudinal crest, curved somewhat outward, to end near the beginning of the last fourth of the bone, in the upper part of the popliteal surface, about midway between the lateral margins. The distal extremity of the femur is expanded to the full width of the proximal extremity, chiefly on the inner side, the internal border of the bone forming a deep concavity above, while the external border of the bone is gently concave on the middle two-fourths, the first and last fourths gently convex in outline. The distal border of the inner condyle is nearly transverse and straight, thickened internally; the external condyle is narrow, and greatly expanded antero-posteriorly, so that the distal articular surface somewhat resem-

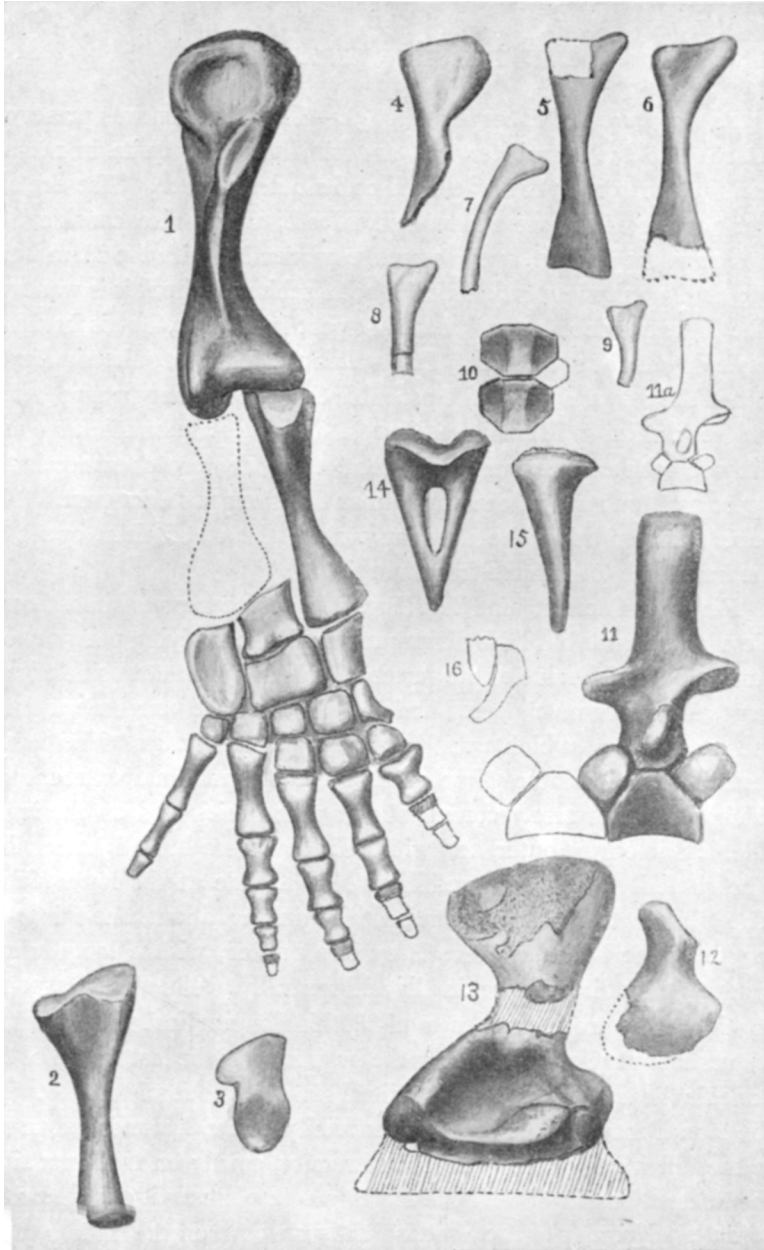


FIG. 5.—*Trematops milleri*. 1, left hind leg, ventral or plantar side; 2, left tibia from without; 3, the same, proximal surface; 4, right second rib; 5, right seventh rib; 6, right eighth rib; 7, seventeenth rib; 8, nineteenth rib; 9, twenty-third rib; 10, twelfth and thirteenth hypocentra, from below; 11, ninth vertebra, from the side, about four-thirds natural size; 11a, the same, about two-thirds natural size; 12, left sacral rib, from above; 13, left innominate, from without; 14 and 15, chevron, from behind and the side, about four-thirds natural size; all figures, save as noted, about two-thirds natural size.

bles an italic letter *L*, with the intercondylar groove in front deep, the popliteal groove shallow. In front, the outer border is convex to the articular surface for the fibula, and the articular surface as a whole is directed ventrad at an angle of about forty-five degrees from the long axis of the femur, and also outward at an angle of about twenty degrees; the articular surface also extends proximad on the ventral side so as to permit a considerable degree of flexion, while complete extension would have been impossible. The considerable depth of the pelvic symphysis raised the acetabular surface some distance from the ground, and doubtless the knee was constantly flexed to a considerable extent.

The tibia is preserved in the matrix in articulation with both the femur and tarsus, but rotated somewhat upon its outer side. Its proximal extremity is much expanded, antero-posteriorly, and also somewhat from side to side. Its articular surface for the femur is slightly concave, sloping obliquely backward and outward from the long axis. Its proximal part in front is broad for the insertion of the stout muscles of the intercondylar groove, while a large surface posteriorly also gave insertion to the flexor muscles. The middle of the shaft of the bone is slender, and nearly circular in cross-section, from which place the bone becomes gradually broader to the distal end, which is thickened and broader from side to side than from before back. The outer border of the bone, as a whole, is nearly straight, or gently concave; the inner border is deeply concave.

As already stated, the fibula was dislodged from its position. Lying close by the inner side of the tibia, is a flattened bone, imperfect at one side, which is evidently the distal extremity of a fibula. The part preserved is remarkably broad, much thinner on its outer side, thickened, shaft-like on the inner, where broken off. Distally it shows two thickened, apparently articular borders separated by a thinner, non-articular margin.

The tarsus and foot lie almost perfectly in position, the tibiale slightly turned outward by the rotation of the tibia, and the fifth toe partially turned under the fourth and third. Lying as they do upon the sides of the fourteenth, fifteenth, and sixteenth vertebrae, the bones are somewhat uneven, because of the rugosities. There are twelve tarsal bones, three in the proximal, four in the middle, and five in the

distal row, a number found by Baur in *Archegosaurus*, but otherwise unknown among air-breathing vertebrates. Of the proximal row the tibiale is elongate, a little broader proximally, with a thickened, rounded internal margin, articulating proximally with the tibia, distally with the first centrale, and internally with the second and third centralia. The intermedium is large, with a thickened, oblique face for union with the fibula proximally, a free rounded border opposite the distal part of the tibia, articulating distally with the large centrale, and externally with the fibulare, leaving, however, a small opening for the passage of vessels. The fibulare is elongate antero-posteriorly, and is rather broad; it articulates proximally, on the upper side, with the fibula, internally, above, with the intermedium, distally with the fourth and fifth distalia, and between them and the intermedium with the large centrale. The proximal centrale is one of the largest bones of the tarsus; it is somewhat broader on the inner than on the outer end, articulating proximally with the intermedium, internally with the tibiale, externally with the fibulare, and distally with the two outer centralia. The innermost of these is the smallest, articulating between the tibiale and the first distal, and, on the outer side, with another centrale. This is an unusual position for a centrale, and I have endeavored to find in the small bone some evidence of extraneous origin, but am quite convinced that it really belongs in this place, as otherwise the space it occupies must have been unossified. The median distal centrale is the largest of the three distal centralia, and is nearly square in outline; it articulates proximally with the tibiale and proximal centrale, on either side with a centrale, and distally with the second distal. Of the distal, the second is the largest and the fifth is the smallest, the third and fourth smaller than the second. Each distal supports its own digit exclusively.

The digits are, it is seen by the figure and the restoration, very short and heavy. The first metatarsal is very characteristic in its broad and short form, resembling more a proximal phalanx, broadly expanded proximally and much constricted in the middle. At its distal extremity there is a fragment of the first phalanx in articulation, the remainder lost. The width of this fragment would indicate the possibility of a second phalanx of very small size. The second metatarsal is much longer than the first, its proximal extremity less

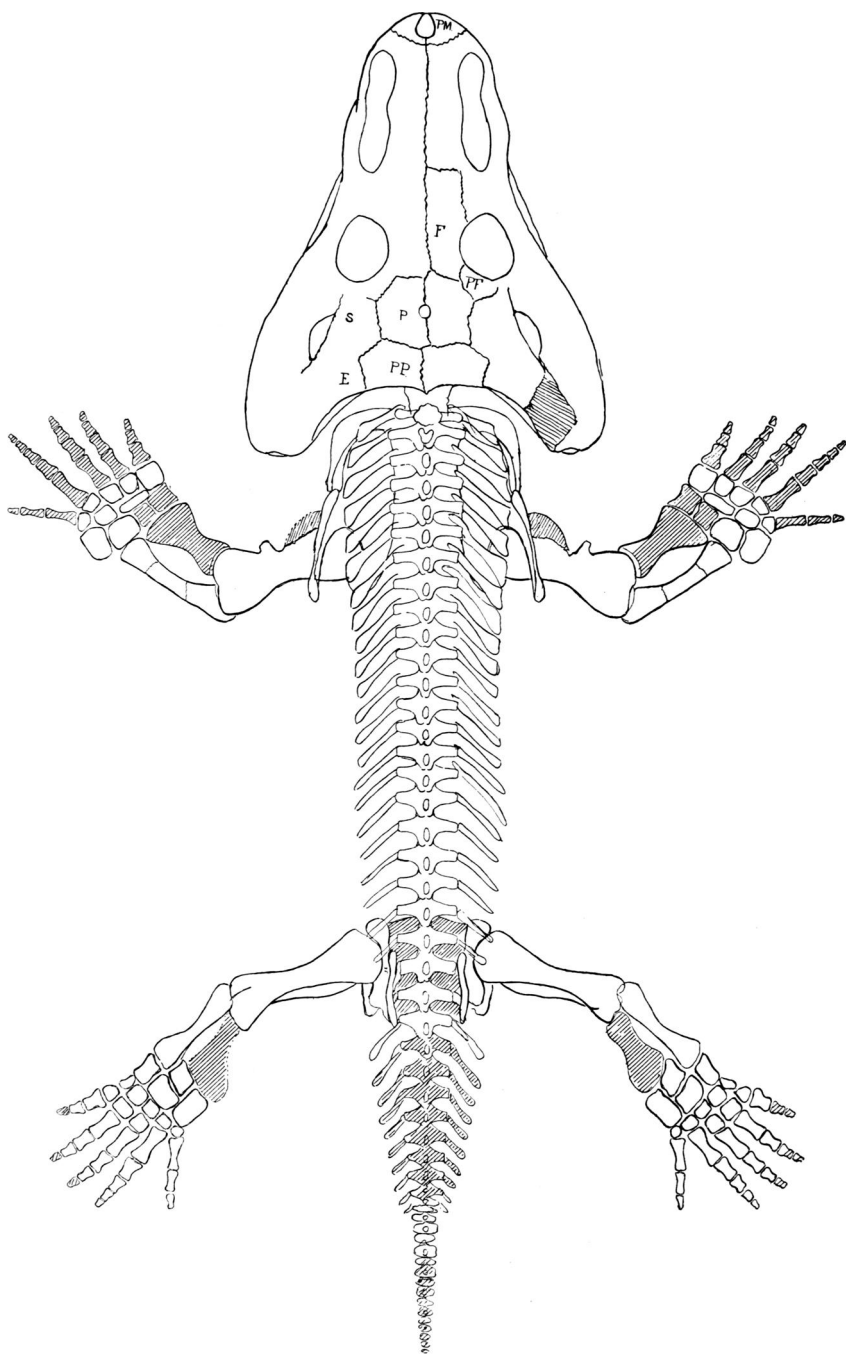


FIG. 6.—*Trematops milleri* Will. Restoration of skeleton; about one-third natural size.

expanded. Its first phalanx is short and expanded, much shorter and smaller than the corresponding phalanx of the third finger. At its distal extremity is preserved the proximal extremity of a very small second phalanx; and there was probably no more present in the living animal. The third metatarsal is much longer than the second, with its proximal extremity more oblique to its long axis. Its distal extremity is quite on a line with the distal extremity of the second metatarsal. The first phalanx is stouter and longer than the first phalanx of the second digit, and a trifle smaller than that of the fourth, its greatest width about equal to two-thirds its length. The second phalanx, preserved entire, is much smaller than the first, and is very short and broad, its width equal to its length; it is but little constricted at its middle. A proximal half or end of a minute third phalanx is also present. It was somewhat pointed in shape, but by no means a claw. The fourth metatarsal is much like the third and of about the same length, its proximal extremity yet more oblique. Its proximal phalanx is a little longer than the first of the third digit, its distal extremity surpassing a little the distal extremity of the third metatarsal. The second phalanx is a little longer but no broader than the second of the third toe. Its third phalanx is about two-thirds the length of the second, but is much narrower distally. The basal of part of the fourth phalanx, a very small bone, is articulated with the third and it is very evident that it was the terminal one, and was very small and in no sense a claw. The fifth toe is slender, and was divaricated in life. In the specimen, while still retaining its articulation with the tarsus, it is turned across the fourth and third metatarsals. Its metatarsal is much narrower, and not more than three-fourths the length of the fourth. Its first phalanx, likewise slender, is about the length of the first phalanx of the second toe, but is much narrower. The second phalanx, much shorter, is narrowed distally, but with a minute terminal knob or expansion. Possibly an ossicle not larger than a pin-head may have articulated here, but probably not.

The actual phalangeal formula of the foot as preserved is, it is seen, 1, 2, 3, 4, 2. It is possible, though not very probable, that the first, second, and fifth digits may have had a minute ossicle at the extremity of each, making the formula, 2, 3, 3, 4, 3. The feet were clawless, the toes ending rather bluntly. The foot as a whole, it is seen, is remark-

able for its broad, short form, and, because of the relatively large size of the tarsus, it must have been very flexible. The absence of true claws, such as occur in some of the Cotylosauria at least, and the Pelycosauria, is what we would expect. The relatively short legs and broad feet were used exclusively in locomotion. The front feet could not have been extended nearly as far forward as the mouth and could have been of no possible use in seizing or holding the animal's prey; and it is quite certain that the creatures did not need claws for locomotion over soft ground.

In the restoration (Fig. 6) the front toes have been copied from the hind ones, and it is not at all probable that there could have been much difference between them. That there were five fingers is shown conclusively, not only from the carpus, but also from the front foot of *Eryops*, as figured by Cope, a form which, in its skeletal structure, is closely allied to *Trematops*. The radius also is given from the same figure by Cope. The fibula is in part conjectural, as is also the length of the tail. It is possible that the head was set even more closely upon the shoulders.

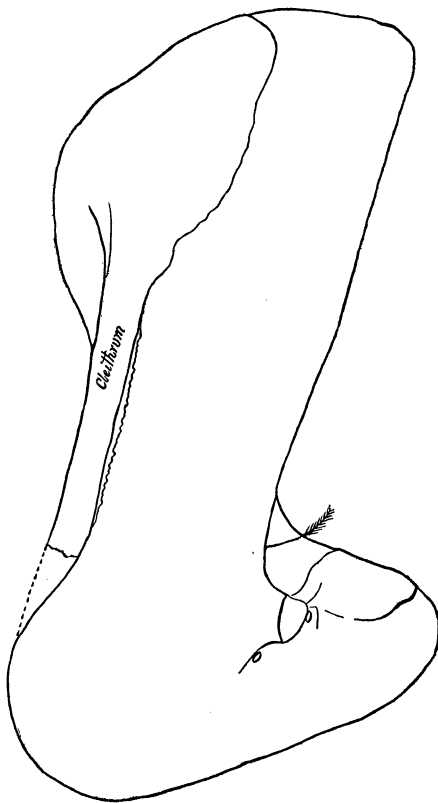


FIG. 7.—Left coraco-scapula of *Eryops latus* Case; about one-third natural size.

From the absence of every indication in the matrix of a dermal armor, it is quite probable that the creature had a bare skin; and the absence of claws and its short legs and feet indicate also that the animal lived not on high dry lands, but about the mud shores and in

the water. The entire absence of a neck, which is characteristic of all the lower vertebrates of the Texas Permian, the large, ungainly but flattened head, the short body and tail, and short, rather stout limbs, all must have given to the creature a very bizarre aspect.

The distinction of *Trematops* from other genera of the rhachitomous amphibians described from Texas seems certain. Its relationship with *Eryops* is evident, but, aside from its smaller size and greater slenderness, the structure of the head separates them widely. From *Acheloma*, which I at first thought might be the same, there seem to be marked differences. Cope's description of *Acheloma* leaves certain parts in doubt, parts of much importance in the discrimination of the two genera, especially the size and shape of the vacuities. He describes the premaxillary teeth as five in number and of large size, whereas in *Trematops* they are six in number and are among the smallest of the whole series. He also states that the humerus of *Acheloma*, a very remarkable thing for an amphibian, has an entepicondylar foramen, whereas there is no trace of such in the present form. Dr. Matthew of the American Museum has very kindly compared the type of *Acheloma*, at my request, and confirms these details, and also informs me that the skull is different in shape from the figure sent him of *Trematops*. I have no hesitation, hence, in giving to the present specimen the generic name *Trematops*, chosen in reference to the numerous vacuities of the upper side of the skull.

A further discussion of the habits and relationships of *Trematops* and *Eryops* will be given in a future paper, after other forms have been described, especially a nearly perfect skeleton, with all its bones in natural relations, of a small species of *Pariotichus*, which will furnish the subject for the next paper of this series.